GEOLOGICAL SURVEY CIRCULAR 891

Coal Resource Classification System of the U.S. Geological Survey

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By Gordon H. Wood, Jr., Thomas M. Kehn,
M. Devereux Carter, and William C. Culbertson

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United States Department of the Interior
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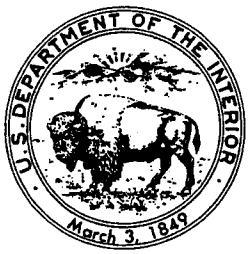

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FOREWORD

In order to use coal resource terms with precision and common understanding and to compare resource data effectively, the authors developed a standardized, definitive, broadly applicable classification system to derive uniform, coordinated coal resource estimates. The principles of the system for all mineral resources are given in USGS Circular 831. Personnel engaged in coal resources work are to use the definitions, criteria, guidelines, and instructions incorporated in this coal resource classification system in all U.S. Geological Survey publications.

Director, Geological Survey

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By GORDON H. WOOD, JR., THOMAS M. KEHN, M. DEVEREUX CARTER, and WILLIAM C. CULBERTSON

INTRODUCTION

Coal is the most abundant fossil fuel in the United States. Knowledge of the size, distribution, and quality of the Nation's coal resources is important for governmental planning; industrial planning and growth; the solution of current and future problems related to air, water, and land degradation; and for meeting the short- to long-term energy needs of the country. Knowledge of the Nation's coal resources is also important in planning for the exportation and importation of fuel.

Many estimates have been made of the coal resources of the Nation, the resources of other nations, and for the world as a whole. Because of differing systems of resource classification, these estimates vary greatly in magnitude within this Nation and other nations; geologic analysis shows some of these estimates to be little more than educated guesses. The accompanying coal resource classification system of the U.S. Geological Survey is recommended as an aid in solving the problems caused by the differing systems.

A detailed resource classification system should identify deposits of coal by areal location, distance from points of information, thicknesses of coal and overburden, rank and quality, and estimates of quantity. Classes in the system, furthermore, should impart some idea as to economic, technologic, legal, and environmental factors affecting the availability of coal.

A coal resource classification system was published jointly by the U.S. Bureau of Mines and the U.S. Geological Survey in 1976 as Geological Survey Bulletin 1450–B and was believed to be a successful modification of an already existing system into the ideal system. However, Bulletin 1450–B left unanswered many questions concerning how to estimate coal resources and did not provide sufficient criteria, guidelines, and a methodology so that comparable estimates would be obtained by all workers using the same data.

The Survey and the Bureau of Mines decided in 1977 that the coal resource classification system, as outlined in Bulletin 1450–B, should be revised and expanded to provide a more definitive and less ambiguous coal resource classification system. The revision was to document standard definitions, criteria, guidelines, and methods to be used in estimating coal resources. Standardization of the elements of the system should result in comparable estimates by different workers using the same data.

In 1980, the two agencies published Circular 831, "Principles of a Resource/Reserve Classification for Minerals" (U.S. Geological Survey, 1980). The circular, which outlines a classification system for all mineral commodities, filled the classification needs of the Bureau of Mines, which was no longer responsible for coal resource classification, and was the basis for this revision of the coal resource classification system by the Geological Survey. The revision, embodied in this report, has two main objectives: (1) to provide detailed information lacking in Bulletin 1450–B; and (2) to provide standard definitions, criteria, guidelines, and methods required for uniform application of the principles outlined in Circular 831.

HISTORY OF THE CLASSIFICATION SYSTEM

Almost since their inceptions in 1879 and 1920, respectively, the U.S. Geological Survey and the U.S. Bureau of Mines have conducted modest ongoing programs in coal resource estimation and analysis. Between

1909 and World War II, tonnage estimates of the coal resources and reserves of the United States were summary totals derived for areas from estimates that were calculated by gross statistical methods. These early estimates were inadequate for the needs of the 1940's because they did not separate thin from thick coal beds, distinguish shallow from deeply buried coal, separately quantify identified resoures and undiscovered resources, or discriminate the quality and rank of coal on the basis of physical and chemical criteria.

After World War II, requests from the public indicated the need for more detailed information about the occurrence, distribution, and availability of the Nation's coal resources. These requests indicated that a more detailed coal classification system was needed and that it should be based on bed-by-bed analysis of thicknesses of coal and overburden, reliability (distance from control points) of areal data, rank of coal, and several chemical parameters related to determining quality and usage. As a result, ongoing programs of the Geological Survey and the Bureau of Mines for geologic mapping and engineering evaluation were expanded, and programs for appraising the coal resources of the Nation on a State-by-State and a bed-by-bed basis were initiated.

After much consultation with potential users, the Geological Survey and the Bureau of Mines revised their procedures and prepared new definitions, criteria, and guidelines to be followed in estimating coal resources. The main elements of the programs used after World War II to 1976 were as follows:

1. Estimates of resources and reserves were based on existing information. Initially, attempts were not made to estimate the Nation's total coal resources or reserves; however, such estimates were long-term objectives.
2. Estimates of resources and reserves were prepared on a State-by-State basis.
3. Estimates of resources and reserves were divided into precisely defined categories such as rank, thicknesses of coal and overburden, and distance from points of information.

The estimates of coal resources and reserves from World War II to 1976 were prepared in formats suitable for use by geologists and engineers, coal specialists, and economists working for the coal industry and government. These formats included geologic maps, coal bed maps, tables, and diagrams of resource and reserve data segregated into categories suitable for comparison with similarly categorized data from other sources.

Experience with the classification system utilized from World War II until 1976 gradually showed the need for still greater detail. It also showed the need for rigidly enforced standards that would lessen individual geologic and engineering judgments in the interpretation of data and methods. Adoption of such standards should result in reproducible and comparable estimates from the same data and would allow adoption of computer technology.

In 1976, the Geological Survey and the Bureau of Mines adopted a modification of the 1944–75 system by publishing U.S. Geological Survey Bulletin 1450–B titled "Coal Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey." This bulletin has been the standard reference for coal resource/reserve work by many Federal and State agencies.

COAL RESOURCE CLASSIFICATION SYSTEM

The classification system presented herein is an expansion of the system adopted in 1976. It employs a concept by which coal is classified into resource/reserve base/reserve categories on the basis of the geologic assurance of the existence of those categories and on the economic feasibility of their recovery. Categories are also provided for resources/reserve base/reserves that are restricted because of legal, environmental, or technologic constraints. Geologic assurance is related to the distance from points where coal is measured or sampled; thicknesses of coal and overburden; knowledge of the rank, quality, depositional history, areal extent, and correlations of coal beds and enclosing strata; and knowledge of the geologic structure. Economic feasibility of recovery is affected not only by such physical and chemical factors as thicknesses of coal and overburden, quality of coal, and rank of coal, but also by economic variables—such as price of coal, cost of equipment, mining, labor, processing, transportation, taxes, and interest rates, demand for and supply of coal, and weather extremes—and by environmental laws, restrictions, and judicial rulings. For example, the Clean Air Act of 1970 issued standards that severely limited the emission of sulfur by new coal-burning powerplants and, as a result, made the low-sulfur, low-rank coal deposits of the Northern Great Plains economically competitive. Similarly, environmental restrictions on the surface mining of coal and the need for adequate reclamation of mined areas has adversely affected the economic and technologic feasibility of extracting coal from some near-surface deposits.

The classification system is designed to quantify the

total amounts of coal in the ground before mining began (original resources) and after any mining (remaining resources). It is also designed to quantify the amounts of coal that are known (identified resources) and the amounts of coal that remain to be discovered (undiscovered resources). The system also provides for recognizing amounts of coal that are (1) standard distances from points of thickness measurements—measured, indicated, inferred, and hypothetical; (2) similar to coal currently being mined (reserve base and inferred reserve base); (3) economically recoverable currently (reserves and inferred reserves); (4) potentially recoverable with a favorable change in economics (marginal reserves and inferred marginal reserves); and (5) subeconomic because of being too thin, too deeply buried, or lost-in-mining. Finally, the system allows tabulation of coal amounts that are restricted from mining by regulation, law, or judicial ruling.

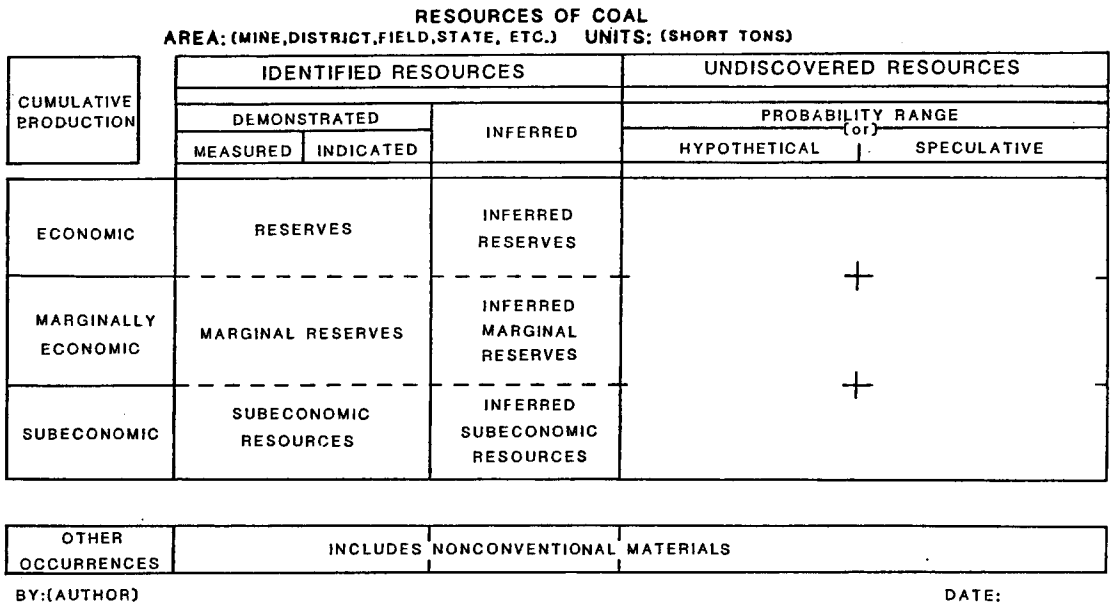
Two factors have created difficulties in categorizing resources and reserves in all classification systems. First, most geologists and engineers who classify resources and reserves are not experts in the economics of mining, transportation, processing, and marketing. Second, economic conditions change with time, so that the economic viability of coal is relatively fluid. For example, subeconomic resources of today can become reserves of tomorrow as the price of coal rises; conversely, reserves can become subeconomic resources as the price of coal drops. Finally, changing regulations, laws, and judicial rulings can affect mining, transportation, processing, and marketing, and thus the classification of coal resources. The concept of a reserve base was developed to alleviate these difficulties (U.S. Geological Survey, 1976, p. B2).

The reserve base is identified coal defined only by physical and chemical criteria such as thicknesses of coal and overburden, quality, heat value, rank, and distance from points of measurement. The criteria for thickness of coal and for overburden have been selected so that the reserve base includes some currently subeconomic coal. The concept of the reserve base is to define a quantity of in-place coal, any part of which is or may become economic depending upon the method of mining and the economic assumptions that are or will be used. An additional purpose is to aid in long-range public and commercial planning by identifying coal suitable for economic recovery.

Thus, resource specialists need not expend their time identifying the component parts of coal deposits that are currently economically recoverable (reserves) because the reserve base category contains much of the coal that will be classed as reserves in the foreseeable future. Those required to classify coal as being economically recoverable, marginally recoverable, or subeconomic can examine reserve base estimates to locate such coal.

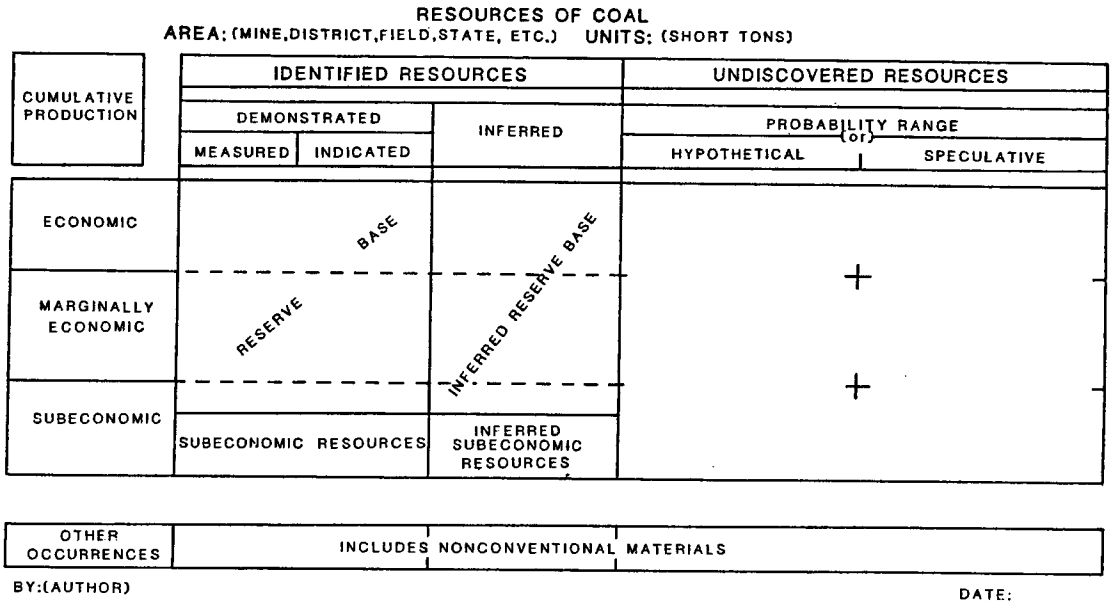
Figures 1 and 2 are conceptual diagrams modified from Circular 831 (U.S. Geological Survey, 1980) that show the relationship of the various classes of coal resources, the reserve base, and reserves. The classes are categorized in both figures according to their degree of geologic assurance (geologic assurance or proximity to points of control increases to the left), and according to their degree of economic feasibility of recovery (economic feasibility of mining increases upward). The resource/reserve base/reserve categories (classes) that can be used are not limited to those shown in figures 1 and 2 nor to the categories described in succeeding pages. For example, a particular bed of coal may be identified as being low-sulfur (0–1 percent), low-ash (0–8 percent), high-volatile A bituminous, and premium coking coal; other beds of coal may be identified as medium-sulfur (1.1–3.0 percent), high-ash (>15 percent), high-volatile bituminous, surface-minable cannel coal, and so forth. The ability of the classification system to precisely describe the characteristics of a body of coal allows the coal resources of the United States to be divided into many hundred resource classes or categories.

The hierarchy of coal resources shown in figure 3 illustrates the conceptual relationships between the classes of resources as distinguished by their definitions and criteria. Examination of figures 1, 2, and 3 makes clear that each succeeding class in the hierarchy from original and remaining resources to reserves is included in the overlying classes. Original resources include remaining resources and cumulative depletion. Remaining resources include identified and undiscovered resources (divisible into hypothetical and speculative resources). Identified resources include measured, indicated, inferred, and demonstrated resources. Measured and indicated resources contain coal classed as reserve base, and inferred resources contain coal classed as inferred reserve base. Some measured, indicated, and inferred resources are subeconomic because they are too thin to mine or are buried too deeply to be mined by current extraction techniques; furthermore, parts of the reserve base and inferred reserve base are potentially subeconomic because they will be lost-in-mining. Reserves and inferred reserves are economically minable as of the time of classification. The reserve base and inferred reserve base also contain some coal that is believed to be potentially economic and which is classed as marginal and inferred marginal reserves.



A PORTION OF RESERVES OR ANY RESOURCE CATEGORY MAY BE RESTRICTED FROM EXTRACTION BY LAWS OR REGULATIONS.

FIGURE 1.—Format and classification of coal resources by reserves and subeconomic resources categories.



A PORTION OF RESERVES OR ANY RESOURE CATEGORY MAY BE RESTRICTED FROM EXTRACTION BY LAWS OR REGULATIONS.

FIGURE 2.—Format and classification of coal resources by reserve and inferred reserve bases and subeconomic and inferred subeconomic resources categories

GLOSSARY OF COAL CLASSIFICATION SYSTEM AND SUPPLEMENTARY TERMS

Some of the following general definitions of coal resources and supplementary terms are amplified elsewhere in this report by criteria and guidelines for usage. The criteria and guidelines may be revised periodically to reflect changing national needs without affecting the definitions.

All definitions herein refer only to usage in this coal resources classification system and are not intended as definitions of the terms relative to any other usage.

Comparative values for units in the metric and English (U.S. Customary) systems of measurement are based on the Handbook of Chemistry and Physics by R. C. Weast (1971, p. F-242-F-263).

Note.—Glossary terms and specific criteria are cross-referenced within this report. To aid the reader, glossary items, beginning below, are printed in **boldface** type, and specific criteria, beginning on p. 24, are printed in ***boldface italics***.

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accessed.—Coal deposits that have been prepared for mining by construction of portals, shafts, slopes, drifts, and haulage ways; by removal of overburden; or by partial mining. See **virgin coal.**

acre.—A measure of area in the United States: 43,560 square feet; 4,840 square yards; 4,046.856 square meters; 0.4046856 hectare; 0.0015625 square mile; 0.0040468 square kilometer.

acreage.—The number of acres at the ground surface

acre-foot (acre-ft).—The volume of coal that covers 1 acre at a thickness of 1 foot (43,560 cubic feet; 1,613.333 cubic yards; 1,233.482 cubic meters). The weight of coal in this volume varies according to **rank.**

acre-inch (acre-in.).—The volume of coal that covers 1 acre at a thickness of 1 inch (3,630 cubic feet; 134.44 cubic yards; 102.7903 cubic meters). The weight of coal in this volume varies according to **rank.**

agglomerating.—Coal that, during volatile matter determinations, produces either an agglomerate button capable of supporting a 500-gram weight without pulverizing, or a button showing swelling or cell structure.

anthracite or **anthracitic.**—A rank class of nonagglomerating coals as defined by the American Society for Testing and Materials having more than 86 percent fixed carbon and less than 14 percent volatile matter on a dry, mineral-matter-free basis. (*Anthracite* is preferred usage). This class of coal is divisible into the semianthracite, anthracite, and meta-anthracite groups on the basis of increasing fixed carbon and decreasing volatile matter. (See table 1.)

ash.—The inorganic residue remaining after complete incineration of coal.

ash content.—The percentage of a laboratory sample of coal remaining after incineration to a constant weight under standard conditions following D-2795-69 (ASTM, 1981, p. 335-342).

ash free.—A theoretical analysis calculated from basic analytical data expressed as if the total ash had been removed.

as-received condition or **as-received basis.**—Represents an analysis of a sample as received at a laboratory.

assess.—To analyze critically and judge definitively the geologic nature or economic potential, significance, status, quality, quantity, potential usability, and other aspects of coal resources and reserves.

assessment.—A critical analysis based on integrating, synthesizing, evaluating, and interpreting all available data aimed at a judgment of the geologic nature or economic potential of the coal resources and reserves of an area, field, district, basin, region, province, county, state, nation, continent, or the world. An *assessment* differs from an estimate, which is a determination of the amount of coal in an area. An estimate or estimates may be the principal data used to assess the coal resources and reserves of an area. See **economic assessment** and **geologic assessment.**

auger mining.—A method often associated with contour strip mining to recover additional coal after the overburden to coal ratio has become too great for further contour mining. Coal is produced by boring into the coal bed much like a carpenter's wood bit bores into wood. An auger consists of a cutting head and screw-like extensions.

bed.—All the coal and partings lying between a roof and floor. The terms "seam" and "vein" should not be used.

bench.—A subdivision and (or) layer of a coal bed separated from other layers by partings of non-coal rock.

bituminous coal.—A rank class of coals as defined by the American Society for Testing and Materials (ASTM) high in carbonaceous matter, having less than 86 percent fixed carbon, and more than 14 percent volatile matter on a dry, mineral-matter-free basis and more than 10,500 Btu on a moist, mineral-matter-free basis. This class may be either agglomerating or nonagglomerating and is divisible into the high-volatile C, B, A; medium; and low-volatile bituminous coal groups on the basis of increasing heat content and fixed carbon and decreasing volatile matter. (See table 1.)

bone coal or **bone.**—Impure coal that contains much clay or other fine-grained detrital mineral matter (ASTM, 1981, D-2796, p. 344). See **impure coal.**

Discussion: The term *bone coal* has been erroneously used for cannel coal, canneloid coal, and well-cemented to metamorphosed coaly mudstone and (or) claystone. *Bone coal* has also been applied to carbonaceous partings. The term "impure coal" accompanied by adjective modifiers such as "silty,"

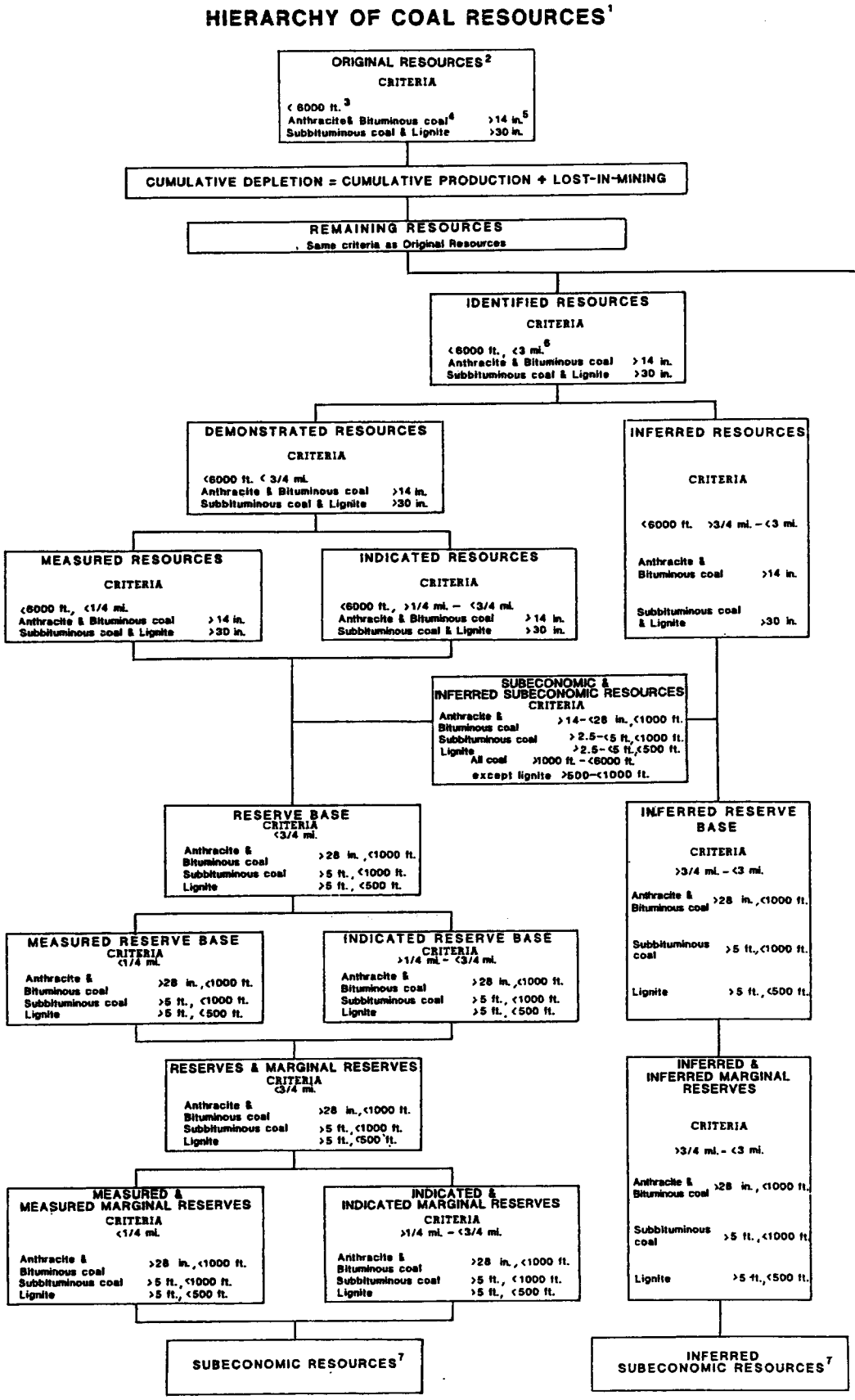

FIGURE 3.—Heirarchy of coal resources and

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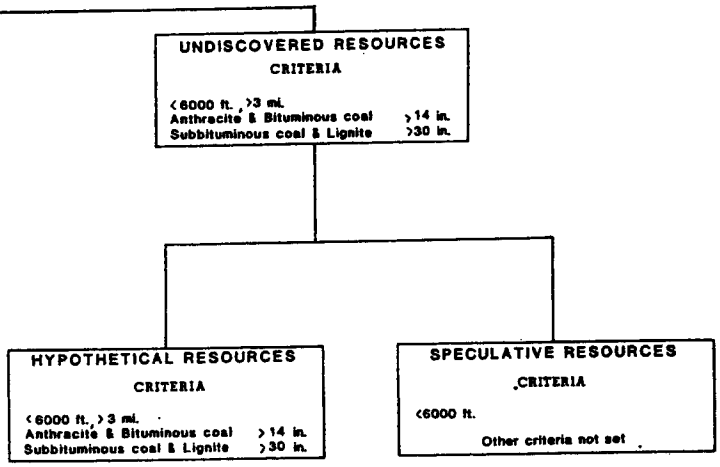

1. Coal resource terms are defined in glossary.
2. Resources before mining.
3. 500 ft., 1000 ft., and 6000 ft. Depth of burial or overburden thickness.
4. Anthracite, bituminous, subbituminous, and lignite are ranks of coal. See Table 1.
5. 14 in., 28 in., 30 in., and 5 ft. are minimum thicknesses of coal.
6. 1/4 mi., 3/4 mi., and 3 mi. are distances from points of measurement of coal thickness.
7. Includes coal left in room and pillar mining, in property barriers, coal too thick to be recovered completely by conventional mining, and mine and preparation plant waste.

NOTE

OTHER OCCURRENCES

Includes coal:

a) less than minimum thickness at any depth

b) containing more than 33 weight percent ash on dry basis

c) buried at depths of more than 6,000 feet

Estimated tonnage, where calculated, is to be reported as "Other Occurrences" and not as resources, unless mined. Where mined, tonnage quantity is included in reserve base and reserve estimates.

criteria for distinguishing resource categories.

"shaly," or "sandy," is the preferred usage because the definition of *bone coal* does not specify the type or weight percentages of impurities.

British thermal unit (Btu).—The quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit (°F) at, or near, its point of maximum density of 39.1° F (equivalent to 251.995 gram calories; 1,054.35 Joules; 1.05435 kilojoules; 0.25199 kilocalorie).

burn line.—The contact between burned and unburned coal in the subsurface. In the absence of definitive information, the subsurface position of a *burn line* is assumed to be vertically below the surface contact between unaltered and altered rocks. See **clinker.**

calorie (cal).—The quantity of heat required to raise 1 gram of water from 15° to 16° Celsius. A calorie is also termed gram calorie or small calorie (equivalent to 0.00396832 Btu; 4.184 Joules; 0.001 kilogram calorie).

clinker.—Baked or fused rock formed from the heat of a burning underlying coal bed.

coal.—A readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume of carbonaceous material, including inherent moisture. It is formed from plant remains that have been compacted, indurated, chemically altered, and metamorphosed by heat and pressure during geologic time.

Discussion: Differences in the kinds of plant materials, in the degree of metamorphism (rank), and in the range of impurities are characteristic of *coal* and are used in coal classification. Impure coal/coaly material containing more than 33 weight percent ash is excluded from resources and reserve estimates unless the ash is largely in associated partings so that the *coal* is cleanable to less than 33 weight percent ash.

coal bed.—See **bed.**

coal field.—A discrete area underlain by strata containing one or more coal beds. (See figs. 5 and 6.)

coal measures.—Strata containing one or more coal beds.

coal province.—An area containing two or more coal regions. (See fig. 8.)

coal region.—An area containing one or more coal fields. (See fig. 7.)

coal reserves.—See **reserves.** (See also *reserves*, p. 30.)

coal zone.—A series of laterally extensive and (or) lenticular coal beds and associated strata that arbitrarily can be viewed as a unit. Generally, the coal beds in a *coal zone* are assigned to the same geologic member or formation.

coke.—A gray, hard, porous, and coherent cellular-structured solid, primarily composed of amorphous carbon. *Coke* is combustible and is produced by destructive distillation or thermal decomposition of certain bituminous coal that passes through a plastic state in the absence of air.

concentration.—A greater than normal accumulation of substances such as (1) coal, (2) elements, (3) compounds, and (4) minerals. In coal resource terminology, *concentration* is used in two senses: (1) concentrations of coaly material into beds that are minable, and (2) concentrations of elements, compounds, and minerals that may add or detract from the value of the extracted coal. A *concentration* of a substance always exceeds the average content of that substance in the Earth's crust.

consolidated coal.—See **lignite.**

content.—The amount of ash, an element, an oxide, other types of compounds, or a mineral in a unit amount of coal, expressed in parts per million or percent. Also refers to the heat value of coal as expressed in Joules per kilogram (J/kg), kilojoules per kilogram (kJ/kg), British thermal units per pound (Btu/lb), or calories per gram (cal/g).

control point.—A **point of measurement**, a **point of observation**, or a sampling point.

correlate, correlation.—Demonstration of the apparent continuity of a coal bed between control, measurement, or sampling points by showing correspondence in character and stratigraphic position.

Discussion: Correlations of coal beds are based on a knowledge of the stratigraphy of the coal beds and of the enclosing rocks and of the unique characteristics of individual coal beds. Confidence in correlations increases as the knowledge and abundance of data increases. Where a coal bed is continuously exposed along an outcrop or strip-mine face, continuity of the coal bed becomes an established fact and not a *correlation*.

Where data indicate that correlation of a coal bed is possible or probable among data points within an area, an estimate of the resources of that coal bed can be made for the entire area. However, where a coal bed at single data point cannot be correlated with beds at other data points, or where there is only one data point, resources can be calculated for that coal bed using the single data point as the center of circles defining measured, indicated, and inferred.

cumulative depletion.—The sum in tons of coal extracted and lost-in-mining to a stated date for a

specified area or a specified coal bed. (See ***cumulative depletion***, p. 25; and fig. 3.)

cumulative production.—The sum in tons of coal extracted to a stated date for a specified area or a specified coal bed. (See ***cumulative production***, p. 25; and figs. 1, 2, and 3.)

demonstrated.—A term commonly used for the sum of coal classified as measured and indicated resources. Used when not feasible or desirable to subdivide into **measured** and **indicated**. (See figs. 1, 2, and 3.)

demonstrated reserves.—Same as **reserves**. (See also, ***demonstrated reserves***, p. 25; and figs. 1, 2, and 3.)

demonstrated reserve base.—Same as **reserve base**. (See also ***demonstrated reserve base***, p. 25; and figs. 1, 2, and 3.)

demonstrated resources.—See **resources**. (See also, ***demonstrated resources***, p. 25; and figs. 1, 2, and 3.)

density.—Mass of coal per unit volume. Generally expressed in short tons/acre-foot or metric tons/hectare/square hectometer-meter of coal. See **specific gravity**.

depleted resources.—Resources that have been mined; includes coal recovered, coal lost-in-mining, and coal reclassified as subeconomic because of mining. See **cumulative depletion**. (See also ***cumulative depletion***, p. 25; and fig. 3.)

depth (overburden) categories.—Coal tonnage data are divided into classes by the thickness of overburden: 0–500 feet (0–150 m); 500–1,000 feet (150–300 m); 1,000–2,000 feet (300–600 m); 2,000–3,000 feet (600–900 m); and 3,000–6,000 feet (900–1,800 m). See **overburden**.

Discussion: The depth categories or overburden categories (see table 3, and specific instruction No. 2, p. 33) were decided after consultation among personnel from the U.S. Geological Survey, the Bureau of Mines, and various State Geological Surveys, mining companies, and agencies of foreign nations.

dry, mineral-matter-free basis.—A type of calculated analytical value of a coal sample expressed as if the total moisture and mineral matter had been removed. *Mineral-matter-free* is not the same as **ash-free**.

economic.—This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

economic assessment.—A critical analysis resulting in a judgment of the economic nature, significance, status, quantity, quality, market, demand, supply, costs, transportation, cash flow, capital, and processing of the coal resources of a mine, area, district, field, basin, region, province, county, state, or nation. See **assessment**.

estimate.—A determination as to the amount or tonnage of coal in an area. The term *estimate* indicates that the quantities of resources are known imprecisely. An *estimate* differs from an assessment, which is an analysis of all data concerning an area's coal resources and reserves with the objective of reaching a judgment about the geologic nature and economic potential of the coal resources and reserves of the area.

existing market conditions.—The relations between production, selling and transportation costs, supply, demand, and profit at any time.

extraction.—The process of removing coal from a deposit.

feasibility.—The possibility of extracting coal.

fixed carbon.—The solid residue, other than ash, obtained by destructive distillation of a coal, determined by definite prescribed methods (ASTM, 1981, p. 183).

floor.—Stratigraphically, the rock immediately underlying a coal bed. Where the bed is overturned, the stratigraphic *floor* is the mining roof.

gasification, underground (in situ).—A method of utilizing coal by burning in place and extracting the released gases, tars, and heat. See **in situ mining**.

geologic assessment.—A critical analysis resulting in a judgment of the geologic nature, significance, status, quality, and quantity of the coal resources of an area, district, basin, region, township, quadrangle, province, county, state or political province, nation, continent, or the world. See **assessment** and **economic assessment**.

geologic assurance.—State of sureness, confidence, or certainty of the existence of a quantity of resources based on the distance from points where coal is measured or sampled and on the abundance and quality of geologic data as related to thickness of overburden, rank, quality, thickness of coal, areal extent, geologic history, structure, and correlations of coal beds and enclosing rocks. The degree of assurance increases as the nearness to points of control, abundance, and quality of geologic data increases.

geologic evidence.—Information derived from geologic observations that can be used to substantiate the existence, size, depth, attitude, structure, tonnage, and physical and chemical characteristics of a body of coal.

geologic identification.—State of being identified as to location, areal extent or size, depth, volume, quantity, magnitude, and quality of coal resources.

grade.—A term indicating the nature of coal as mainly determined by the sulfur content and the amount and type of ash. This term is not recommended for usage in coal resource estimations; definitive statements as to the contents and types of sulfur and ash are preferable. Statements indicating high, medium, or low grade are inappropriate without documentation. See **quality**.

heat value or heat of combustion.—The amount of heat obtainable from coal expressed in British thermal units per pound, joules per kilogram, kilojoules or kilocalories per kilogram, or calories per gram. To convert Btu/lb to kcal/kg, divide by 1.8. To convert kcal/kg to Btu/lb, multiply by 1.8.

hectare (ha) or square hectometer (hm^2).—A metric unit of area equal to 10,000 square meters; 0.010 square kilometer; 2.4710538 acres; 107,639.10 square feet; 11,959.9 square yards; 0.003861 square mile.

high-ash coal.—Coal containing more than 15 percent total ash on an as-received basis. See **ash-content, medium-ash coal,** and **low-ash coal.**

high-sulfur coal.—Coal containing 3 percent or more total sulfur on an as-received basis. See **low-sulfur coal** and **medium-sulfur coal.**

high-volatile bituminous coal.—Three related rank groups of bituminous coal as defined by the American Society for Testing and Materials which collectively contain less than 69 percent fixed carbon on a dry, mineral-matter-free basis; more than 31 percent volatile matter on a dry, mineral-matter-free basis; and a heat value of more than 10,500 Btu per pound on a moist, mineral-matter-free basis. (See table 1.)

hypothetical.—A low degree of geologic assurance. Estimates of rank, thickness, and extent are based on assuming continuity beyond inferred. Estimates are made, not exceeding a specified depth beyond coal classed as inferred, by projection of thickness, sample, and geologic data from distant outcrops, trenches, workings, and drill holes. There are no measurement sites in areas of hypothetical coal. Used as a modifier to resource terms. See **resources** and **undiscovered.** (See also figs. 1, 2, and 3.)

hypothetical resources.—See Undiscovered Resources, p. 20; (See also ***hypothetical resources***, p. 25; and figs. 1, 2, and 3.)

identified resources.—See Identified Resources, p. 19; (See also ***identified resources***, p. 25; and figs. 1, 2, and 3.)

impure coal.—Coal having 25 weight percent or more, but less than 50 weight percent ash on the dry basis (ASTM, 1981, D-2796, p. 344). *Impure coal* having more than 33 weight percent ash is excluded from resource and reserve estimates unless the coal is cleanable to less than 33 weight percent ash. See **bone coal.**

indicated.—A moderate-degree of geologic assurance. Estimates of quantity, rank, thickness, and extent are computed by projection of thickness, sample, and geologic data from nearby outcrops, trenches, workings, and drill holes for a specified distance and depth beyond coal classed as measured. The assurance, although lower than for measured, is high enough to assume continuity between points of measurement. There are no sample and measurement sites in areas of indicated coal. However, a single measurement can be used to classify coal lying beyond measured as *indicated* and to assign such coal to resource and reserve base categories (fig. 4). Used as a modifier to resource terms.

indicated reserves and indicated marginal reserves.—See **reserves** and **indicated.** (See also ***indicated reserves*** and ***indicated marginal reserves***, p. 25; and figs. 1, 2, and 3.)

indicated reserves base and indicated marginal reserve base.—See **reserve base.** (See also ***indicated reserve base***, p. 26; and figs. 1, 2, and 3.)

indicated resources.—See Indicated Resources, p. 19. (See also ***indicated resources***, p. 26; and figs. 1, 2, and 3.)

inferred.—A low-degree of geologic assurance. Estimates of quantity, rank, thickness, and extent are based on inferred continuity beyond measured and indicated for which there is geologic evidence. Estimates are computed by projection of thickness, sample, and geologic data from distant outcrops, trenches, workings, and drill holes for a specified distance and depth beyond coal classed as indicated. There are no sample and measurement sites in areas of inferred coal. However, a single measurement can be used to classify coal lying beyond indicated as *inferred* and to assign such coal to inferred resource and inferred reserve base categories (fig. 4). Used as a modifier to resource terms.

inferred reserves and inferred marginal reserves.—See subdivisions of **reserves.** (See also ***inferred reserves***, p. 26, and ***inferred marginal reserves***, p. 26; and figs. 1, 2, and 3.)

inferred reserve base.—See **reserve base.** (See also ***inferred reserve base***, p. 26; and figs. 1, 2, and 3.)

inferred resources.—See Inferred Resources, p. 19. (See also ***inferred resources***, p. 26; and figs. 1, 2, and 3.)

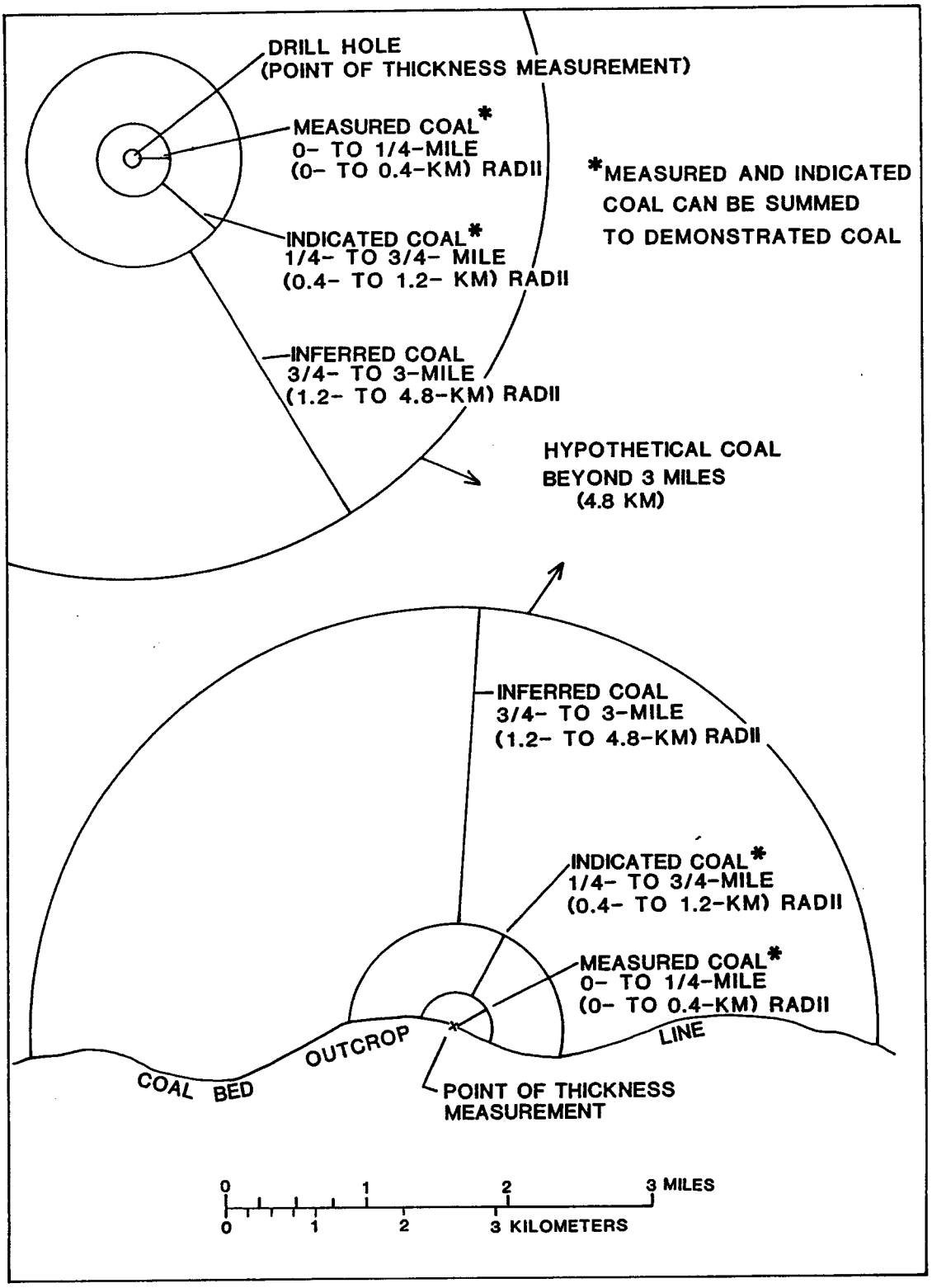

FIGURE 4.—Diagram showing reliability categories based solely on distance from points of measurement.

inferred subeconomic resources.—See Inferred Subeconomic Resources, p. 20. (See also ***inferred subeconomic resources***, p. 31; and figs. 1, 2, and 3.)

in situ.—Refers to coal "in place" in the ground.

in situ mining.—Utilization of coal by burning in place and extracting the gases, tars, and heat.

joule (J).—The basic metric unit of work or energy equal to 1×10^7 ergs, 0.238662 gram calorie, 0.0002386 kilogram-calorie, or 0.0009471 Btu.

kilogram-calorie (kcal).—A metric unit of heat equal to 1,000 gram-calories; 3.9683207 Btu; 4,184 Joules; 4.184×10^{10} ergs; or 4,184 Watt seconds. Also known as "large calorie."

kilogram (kg).—The basic metric unit of weight measurement equal to 1,000 grams; 0.001 metric ton; 2.2046 pounds; 0.0011023 short ton; 0.0009842 long ton.

kilojoule (kJ).—A metric unit of work or energy equal to 1,000 joules; 0.948708 Btu; or 238.662 gram-calories.

known coal.—Coal whose existence has been perceived from measurements and observations at the outcrop, in mines, from drill holes, and from exploratory trenches. Data confirming existence may be projected for several miles (kilometers) if based upon reasonable geologic assumptions. See **identified resources**. Coal fields, basins, regions, provinces, and occurrences of coal in the United States are illustrated in figures 5, 6, 7, and 8.

lignite or **lignitic.**—A class of brownish-black, low-rank coal defined by the American Society for Testing and Materials as having less than 8,300 Btu on a moist, mineral-matter-free basis. (See table 1.) In the United States, *lignite* is separated into two groups: Lignite A (6,300 to 8,300 Btu) and lignite B (<6,300 Btu). *Lignite* is the preferred usage.

long ton.—A unit of weight in the U.S. Customary System and in the United Kingdom equal to 2,240 pounds (1.0160469 metric tons; 1.1200 short tons; 1,016.0469 kilograms). This term is not recommended for use in estimates of coal resources.

lost-in-mining.—Coal remaining in the ground after all extraction is completed. *Lost-in-mining* includes coal that is (1) left to support mine roofs, (2) too thin to mine, (3) unmined around oil, gas, water, and disposal wells, (4) unmined around shafts and electrical and water conduits, (5) unmined as barrier pillars adjacent to mine or property boundaries, (6) unmined adjacent to haulageways, tunnels, airways, and waterways, (7) unmined because of many other unspecified reasons, (8) the unrecovered or unrecoverable part of any coal bed in a mining property that has been or may be extracted, (9) all unrecoverable in beds that closely overlie a mined bed, (10) all unrecoverable in beds that closely underlie a mined bed, (11) unmined between mining properties.

Discussion: According to this system of classification, *lost-in-mining* equals reserve base minus reserves and marginal reserves. Thus, *lost-in-mining* includes all reserve base coal not economically recoverable at the time of classification or not bordering on being economically recoverable. Lost-in-mining coal is subtracted from the reserve base and is divisible into subeconomic coal or noneconomic coal according to its potential for being reclassified as economic. (See fig. 3.)

low-ash coal.—Coal containing less than 8 percent total ash on an as-received basis. See **ash content**, **high-ash coal**, and **medium-ash coal**.

low-sulfur coal.—Coal containing 1 percent or less total sulfur on an as-received basis. See **high-sulfur coal** and **medium-sulfur coal**.

low-volatile bituminous coal.—A rank group of bituminous coal as defined by the American Society for Testing and Materials containing more than 78 percent and less than 86 percent fixed carbon, and more than 14 percent and less than 22 percent volatile matter on a dry, mineral-matter-free basis. (See table 1.)

marginal reserves.—Borders on being economic. See **economic**; general guideline no. 8, p. 32; and subdivisions of **reserves**. (See also ***indicated marginal reserves*** and ***measured marginal reserves***, p. 25 and 27; and figs. 1, 2, and 3.)

measured.—The highest-degree of geologic assurance. Estimates of quantity are computed partly from dimensions revealed in outcrops, trenches, workings, and drill holes and partly by projection of thickness, sample, and geologic data not exceeding a specified distance and depth. Rank is calculated from the results of detailed sampling that may be located at some distance from this type of resource and may be on the same or other coal beds. The sites for thickness measurement are so closely spaced and the geologic character so well defined that the average thickness, areal extent, size, shape, and depth of coal beds are well established. However, a single measurement can be used to classify nearby coal as *measured* (fig. 4). Used as a modifier to resource terms.

measured reserves and **measured marginal reserves.**—See subdivisions of **reserves**. (See also ***measured reserves***, p. 27; ***measured marginal reserves***; p. 27; and figs. 1, 2, and 3.)

measured reserve base.—See **reserve base**. (See also ***measured reserve base***, p. 27; and figs. 2 and 3.)

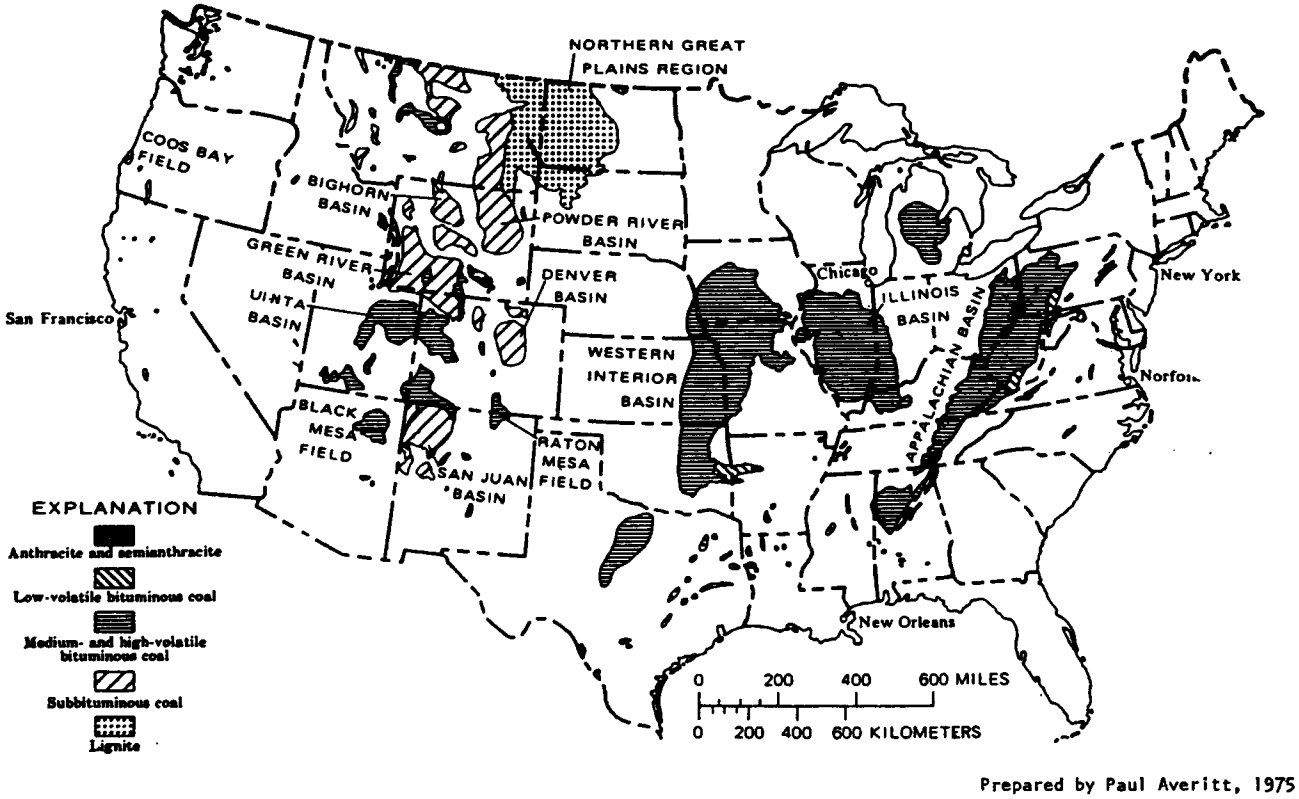

FIGURE 5.—Coal fields of the conterminous United States (from Averitt, 1975).

measured resources.—See Measured Resources, p. 19; (See also ***measured resources***, p. 27; and figs. 1, 2, and 3.)

medium-ash coal.—Coal containing 8 percent to 15 percent ash on an as-received basis. See **ash content**, **low-ash coal**, and **high-ash coal**.

medium-sulfur coal.—Coal containing more than 1 percent and less than 3 percent total sulfur on an as-received basis. See **high-sulfur coal** and **low-sulfur coal**.

medium-volatile bituminous coal.—A rank group of bituminous coal as defined by the American Society for Testing and Materials containing more than 69 percent and less than 78 percent fixed carbon and more than 22 percent and less than 31 percent volatile matter on a dry, mineral-matter-free basis. (See table 1.)

metallurgical coal.—An informally recognized name for bituminous coal that is suitable for making coke by industries that refine, smelt, and work with iron. Other uses are space heating, blacksmithing, smelting of base metals, and power generation. Generally, *metallurgical coal* has less than 1 percent sulfur and less than 8 percent ash on an as-received basis. Most premium *metallurgical coal* is low- to medium-volatile bituminous coal.

metric ton, megagram, tonne, or millier.—A metric unit of weight equal to 1,000 kilograms; 1.1023113 short tons; 0.98420653 long ton; 2,204.6226 pounds. The *metric ton* is the preferred usage.

minable.—Capable of being mined under current mining technology and environmental and legal restrictions, rules, and regulations.

mineral-matter.—The solid inorganic material in coal.

mineral-matter-free basis.—A theoretical analysis calculated from basic analytical data expressed as if the total mineral-matter had been removed. Used in determining the rank of a coal.

mining.—All methods of obtaining coal or its byproducts from the Earth's crust, including underground, surface, and in situ mining.

moist, mineral-matter-free basis.—A theoretical analysis calculated from basic analytical data and expressed as if the mineral-matter had been removed and the natural moisture retained. Used in determining the rank of coal.

moisture, bed.—The percentage of moisture or water in a bed or sample of coal before mining.

moisture content.—The percentage of moisture (water) in coal. Two types of moisture are found in